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U. S. DEPARTMENT OF AGRICULTURE.
DIVISION OF ENTOMOLOGY.
BULLETIN NO. 15.

THE

ICERYA OR FLUTED SCALE,

OTHERWISE KNOWN AS THE

COTTONY CUSHION-SCALE.

[REPRINT OF SOME RECENT ARTICLES BY THE ENTOMOLOGIST AND OF A REPORT FROM THE AGRICULTURAL EXPERIMENT STATION, UNIVERSITY OF CALIFORNIA.]

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LETTER OF SUBMITTAL.

DEPARTMENT OF AGRICULTURE,
DIVISION OF ENTOMOLOGY.
Washington, D. C., June 27, 1887.

SIR: I have the honor to submit for publication Bulletin No. 15, from this Division, prepared under your instructions.

Respectfully,

C. V. RILEY,
Entomologist.

Hon. NORMAN J. COLMAN,
Commissioner of Agriculture.

INTRODUCTION.

This Bulletin consists, 1st, of a reprint of an address delivered at Riverside, Cal., on the treatment of Scale-insects, and more particularly of the Icerya of the Orange, known variously as the "Australian Bug," "Cottony Cushion-scale," "White Scale," "Fluted Scale," &c.; 2nd, a subsequent communication as to its possible origin and synonymy; 3rd, a recent important bulletin from the State University of California on the use of gases against Scale-insects. These papers need no further introduction and are all supplementary to an extended article upon the Icerya, which will appear in my annual report.

The importance of this insect and of all the different scale-insects affecting the Orange in California is such as to justify the republication of these papers, as there is a constant demand for copies of them. The report by Professor Morse on the use of gases is a valuable contribution to the advancement of our knowledge and means of protecting trees from these scale-insects. It may be looked upon as a direct outgrowth of the experiments made for the Department by Mr. D. W. Coquillett, as he had just begun to experiment with gases when his commission ended for want of funds. He subsequently continued these experiments in a private capacity with more or less success, and that which Professor Morse found most satisfactory is, I believe, essentially the same as that previously adopted by Messrs. Coquillett, Craw, and Wolfskill and referred to in my Riverside address. What is said in that address under the head of "Fumigation" will, nevertheless, hold true, no matter how satisfactory the use of these gases may become, and Professor Morse's experiments rather confirm the difficulties which I have indicated in the way of producing a gas which will destroy the Icerya *and its eggs*, as also the danger attending the use of any poisonous gas and the greater expense attending the use of gases, as compared with washes, especially for those who have few trees to treat. Some excellent improvements have been made in the cyclone nozzle, whether for facilitating the change of direction or amount of spray, or whether for ease of cleansing, and I would especially call attention to those of John Croften and L. D. Green, of Walnut Grove, Cal., and of Vermorel, of France.

As Vermorel's arrangement for cleansing is as yet unknown in this country, we may briefly describe it as follows:

The nozzle is pierced below by a circular orifice of from five to six millimeters in diameter, which can be closed by a fly-valve. The reg-

ulating fliers of the valve project on the outside of the apparatus: In the middle of the valve a needle is welded which occupies the axis of the cylinder, and which, when the valve is raised, may be lodged in the aperture with which the stopper of the cylinder is provided. In this way, when the valve is raised up and the lower orifice unmasked, the upper orifice is closed by the needle. When, on the contrary, the valve closes the lower orifice, the aperture of the stopper is uncovered and allows the liquid to pass out.

C. V. R.

THE SCALE-INSECTS OF THE ORANGE IN CALIFORNIA, AND PARTICULARLY THE ICERYA OR FLUTED SCALE, *ALIAS* WHITE SCALE, *ALIAS* COTTONY CUSHION-SCALE, ETC.

[Address by Prof. C. V. Riley before the California State Board of Horticulture, at its semi-annual session at Riverside, Cal., April 12, 1887, as reported in the Pacific Rural Press, April 23, 1887.]

Afternoon session.

The convention met in the afternoon at the Pavilion. It being customary to appoint from the fruit-growers at large two honorary vice-presidents at each meeting, L. M. Holt, of the Riverside Daily Press, and S. C. Evans, of Riverside, were elected to fill those positions. Mr. B. M. LeLong, of Los Angeles, was invited to act as assistant secretary.

The organization having been fully effected, Mr. Cooper, the president, gave a brief statement of the work of the board since its organization. He referred to its previous sessions, and stated that it was the expressed wish of prominent fruit-growers of Los Angeles that its next session be held either in San Diego, Santa Barbara, or Riverside. He had accordingly, in the hope that the well-known interests of the people of this section in horticulture would lead to a better attendance than was sometimes obtained, arranged for the meeting here. The previous session had brought out valuable information, which was being printed, and would be distributed. It was necessary that the mass of newcomers to this portion of the State should be furnished facts which might save them from making expensive blunders. The insect pests are not being overcome as could be wished. He referred to the presence of Professor Riley, one of the most prominent entomologists in the country, and stated that he would give us some valuable information at a subsequent session. He urged co-operation among fruit-growers, and hoped an effort would be made to modify the effect of the interstate commerce bill.

The president then introduced Mr. H. J. Rudisill, a prominent horticulturist of Riverside, who gave an eloquent and very appropriate address of welcome.

At the conclusion of this address the secretary read a well-written and valuable essay prepared by Mrs. H. H. Berger, of San Francisco, on Japanese fruits.

At the conclusion of the essay, Mr. Wilcox, of Santa Clara, suggested that the convention consider the points in Mrs. Berger's paper, and referred to the high character of our fruits exhibited at New Orleans, making special mention of the persimmons there exhibited. They could be grown successfully over the larger portion of the State, and were really a very fine fruit.

Mr. Klee spoke of the fact that most of the Japanese persimmons were grafted on inferior stock, but that we have a better stock upon which to graft in the European persimmon, and that with it we may expect an improvement in the fruit. He had an idea that while the persimmon would grow well in all sections, it would do better in the more humid portions of the State. He suggested that it would be well to experiment with the Japanese oranges in Riverside. Didn't think they would grow of large size, but had excellent points in their favor.

Mr. Klee said the loquat could be grafted on the quince, but did well on its own root. Said the Chinese had better varieties than those with which we are familiar. This fruit could be dried like the fig.

Mr. Starr, of Lugonia, said the persimmon did excellently in the sandy soil of his neighborhood, bearing freely and regularly.

Mr. Holmes thought experience in Riverside had demonstrated the correctness of Mr. Klee's theory that a more humid climate was preferable for this fruit, although it fruited satisfactorily here.

Tuesday's session.

The convention assembled at 9.30 a. m. The first business on the programme was the address of Professor Riley on Scale-insects. He was introduced by President Cooper in a very off-hand but happy and appropriate manner, alluding at some length to the efficient manner in which the professor had conducted the labors of his office, in studying the habits of some of the most destructive insects which have afflicted the farmer and horticulturist, and in devising ways and means to get rid of them.

The professor, on taking the floor, very modestly disclaimed the eulogy which the president had pronounced, and proceeded at once with his address, which was full of valuable information, and which, though quite lengthy, was listened to with the most marked attention throughout.

Professor Riley said:

Mr. PRESIDENT, LADIES, AND GENTLEMEN: When I left Washington it was with the intention of resisting all invitations to speak, as I have been suffering for some time from the effects of overwork and desired quietly to pursue some investigations in relation to insects injuriously affecting fruit culture here and at the same time get rest from exacting office duties. But it was impossible to refuse the urgent appeal of your president, Ellwood Cooper, to address this meeting. I have, however, no formal address to offer you.

The subject announced, namely, "Entomology in its Relation to Horticulture," is one chosen by some enterprising member of your Board, and is altogether too comprehensive to be dealt with without more time and more thought than I have had at command. I shall endeavor to confine my remarks to scale-insects, and particularly to what you know as the White Scale. This is the insect which undoubtedly most concerns you just now, and I have an elaborate article upon it now going through the press at Washington. This, however, would require two or three hours to read, and I will pass over the purely historical and entomological details and touch only upon such points as will probably interest you.

NOMENCLATURE.

There is no doubt whatever about this insect being the *Icerya purchasi*, of Maskell, and its scientific name is, therefore, fixed.* In reference to its popular name, there are several in use, and as between "Australian Bug," "White Scale," and "Cottony Cushion-scale" there is very little choice, and it is, as a rule, useless to endeavor to change popular names that have once come into vogue. So far as they can be changed, however, and with a view of inducing unanimity in the adoption of a single name, it were better to reject all these names and call it the Fluted Scale. There are many Australian bugs and many white scales, some of which, belonging to the genus *Pulvinaria*, equally well deserve that cognomen. Cottony Cushion-scale is both too long to be acceptable and would likewise apply to the species of this last genus, whereas no scale-insect injurious to fruit or other trees, at present existing in this country, secretes its white, waxy matter in such a perfectly *fluted* mass as this. The generic term, Icerya, if once popularized like Geranium, Phylloxera, &c., has the advantage of brevity and still greater accuracy.

GEOGRAPHICAL DISTRIBUTION.

Historical evidence all points to Australasia as the original home of this insect, and its introduction from Australia to New Zealand, Cape Town, South Africa, and California. Nothing was known or published upon the species prior to the seventh decade of this century, and it seems to have first attracted attention almost simultaneously in Australasia, Africa, and America. The evidence as to whether it is indigenous to Australia or New Zealand, or to both, is not yet satisfactory. The first personal knowledge which I had of it was from specimens sent to me in 1872 by Mr. R. H. Stretch, then living in San Francisco, and all the evidence points to its introduction into California by the late George Gordon, of Menlo Park, about the year 1868, and probably from Australia, on *Acacia latifolia*.

* This statement is, of course, based on the assumption that Maskell's *purchasi* is a good species. It may yet prove to be synonym of *sacchari* Signoret.

More light is, however, yet needed on this point, as in a recent letter received from Baron von Müller, of Victoria, he claims that it could not have been imported on Acacia into this State, as all the Acacias in the State have been grown from seed. This is a matter upon which I should like to have definite information from members of this body, if such information is extant.

It is at present widely distributed in the State, and a very full account of its distribution kindly furnished to me by Mr. Matthew Cooke shows that there are some ten infested districts, namely, six in the counties of Marin, San Mateo, Santa Clara, Sacramento, Sonoma, and Napa, and four in the counties of Santa Barbara and Los Angeles. I find that it has also obtained a foothold in a few isolated places around San Diego, from which it may yet be stamped out.

FOOD PLANTS.

A very long list of plants might be enumerated upon which this insect is either found accidentally or upon which it can live more or less successfully. But the list of plants, especially of trees important to us for their products, which are seriously affected by it is comparatively limited, and will include the Acacias, Lime, Lemon, Orange, Quince, Pomegranate, and Walnut. Some few other trees might be added, and it is particularly partial to the Rose and the Nettle; but it is doubtful whether the species could permanently thrive and multiply to an injurious extent on many other trees than those mentioned.

CHARACTERISTICS OF THE INSECTS.

The genus *Icerya* was founded by Signoret, a French entomologist, in 1875, being based upon the single species, *Icerya sacchari* (Guérin), which lives on sugar-cane in the island of Bourbon. This species and the one we are now dealing with are the only two species of the genus, and the diagnosis as given by Signoret, and subsequently elaborated by Maskell, of New Zealand, is incomplete and does not include the characteristics of the male.

In the report already alluded to I have given a very full characterization of the species in all conditions and stages, but the only facts that I need draw attention to on this occasion are, first, that the female undergoes three molts and the male two; *i. e.*, each has one more stage than has hitherto been recognized by entomologists and observers; secondly, that it differs from all other members of its family (Coccidæ) in its extended powers of locomotion in most of its stages; in its extreme hardiness or power of surviving for a given period without food, and in its polyphagous habit, or the ease with which it accommodates itself to so great a variety of plants. These are the three characteristics which most concern you as fruit-growers, and which make it one of the most difficult species to contend with.

MODE OF SPREAD AND DISTRIBUTION.

All young scale-insects are quite active when they first hatch, and most of them at this time are extremely small, and when very thick upon a tree, instinctively, or at least very easily, drop from the terminal twigs and branches. Their specific gravity at this time is so light that they are easily wafted with the wind in their descent. This general truth applies with equal force to the Icerya, which is readily carried from tree to tree and from orchard to orchard by the agency of wind, by running water, or by birds or other insects. Another local means of transport not to be ignored, is upon the clothing of persons engaged in cultivating, upon packages, and upon all implements used, whether in cultivating or harvesting the crop. This particular species also has quite a habit of crawling over the ground, and its local spread is very materially enhanced thereby.

It is carried long distances, however, chiefly by high winds, birds, and commerce, and its introduction from one continent to another has undoubtedly been effected by the latter method upon young trees or cuttings.

NATURAL ENEMIES.

No bird is known yet to attack this insect in California, and but one is mentioned even in Australia, and that upon very slight evidence. Of predaceous insects, a species of Lace-wing (genus *Chrysopa*) has been observed to feed upon it, as also the Ambiguous Lady-bird (*Hippodamia ambigua*). The larva of a little moth, which I have described as *Blastobasis iceryœella*, is also known to feed upon the eggs. Among the Heteroptera, or true bugs, quite a number have been found upon the trees infested with the insect, but none have yet been noticed to feed upon it. The most important of its insect enemies are a species of ear-wig not yet identified, and a number of mites not yet carefully studied.

Of true parasites, none have hitherto been reported, whether in Australia, Africa, or America, but I am glad to announce that two specimens of a minute Chalcid-fly have been bred by me from specimens around Los Angeles, and will be described by my assistant, Mr. L. O. Howard, who makes a specialty of the family, under the name of *Isodromus iceryœ*. The genus is new to our fauna, and the probability is that this little friend was introduced from Australia with its host.*

PREVENTIVE MEASURES.

Most of the members of this society are doubtless aware that for some four years I was conducting a series of very careful experiments with a view of controlling the scale-insects and other insect pests that injuriously affect the orange trees in Florida. This work was carried

* Mr. D. W. Coquillett informs me that he has since reared a Proctotrupid, probably of the genus *Cosmocoma*, from the male pupa.

on through the instrumentality of Mr. H. G. Hubbard, and the Department of Agriculture has published a special report prepared by him upon this subject. All that is said in that report in reference to the value of preventive measures against the scale-insects of that part of our country will apply with equal force here in California.

The value of cleanliness; of thorough cultivation; of pruning judiciously so as to get rid of all dead wood, open the top of the trees to the light and to the sun, and facilitate the spraying of the trees need scarcely be emphasized. There may be some difference of opinion as to the value of pruning, while different kinds of pruning, or no pruning, will have their advocates here as they have had elsewhere. The orange makes, naturally, a very dense head, and in the moist climate of Florida, where they have a much larger average of shade, cloudiness, and moisture than you have here, judicious pruning has all the advantages stated, and whether needed or not in California for the purpose of more fully ripening and maturing the fruit, I am quite satisfied from what I have seen that it is just as much needed to facilitate proper spraying of the trees and to prevent overproduction.

Some years ago, and prior to the discoveries resulting from the investigation in Florida just referred to, the inadequacy of most washes caused many of the orange-growers of that State to cut back their trees most rigorously, leaving little more than the main trunk, in the hope of thus being able to kill out or exterminate the scale-insects that troubled them there. I find that many of your orange-growers are going through the same sad experience and resorting to the same sad means. It is a pity to find men thus re-enacting a farce which has been proved in another part of the country to be quite unnecessary. Such wholesale lopping of limbs requires much labor, and even with the greatest care, which is seldom bestowed upon it, the tree receives an immediate and material injury, and is destined to suffer still more in years to come. Moreover, this radical means often proves futile so far as the results aimed at are concerned, and unless the greatest precaution is taken to properly cover and heal the stumps and to absolutely kill all the insects upon the remaining trunk, as well as those upon the severed branches and the ground, the new growth will soon be as effectually infested as was the old. Many of your own growers have thus lopped or are now cutting back their trees in a very blind way and without the precautions here indicated, on the popular but erroneous supposition that without such precautions they will get rid of the troublesome scales.

The value of shelters in the form of surrounding trees and wind-breaks is, I am sure, just as appreciable here, if not so much to protect from frost and winds, fully as much to protect from infection from scale-insects. A row or tall hedge of coniferous trees, such as your cypress, upon which the scale-insects will not thrive—or, better still, a belt of the same—will often serve as an effectual screen to prevent the young insects from being carried from an infested to an uninfested grove.

Preventing its Introduction.—But, before passing this subject of preventive measures, I must not omit the importance of any effort looking to preventing the introduction of this insect from one section of the country or from one neighborhood to another. No insects so easily bear transit as these scale-insects, and it is eminently true of this particular Icerya.

All the worst species from which they suffer in Florida have been introduced from abroad. Their Long Scale (*Mytilaspis gloverii*) was introduced about the year 1835, their Chaff Scale (*Parlatoria pergandii*) from Bermuda some twenty years later, and their Red Scale (*Aspidiotus ficus*) from Havana in 1879.

We have already seen how this Icerya was introduced into your State from Australia, and the next worst species which you have to deal with, namely, your Red Scale (*Aspidiotus aurantii*), was likewise introduced, so far as the evidence goes, from the same country.

To enumerate merely the different species of insects destructive of your fruit interests that have been introduced from other parts of the country or from other parts of the world would consume too much time, and I cannot attempt to do so. But I would lay stress upon this conviction, which has forced itself upon me after a pretty extended experience in all parts of the country, namely, that however much you should encourage all co-operative efforts to prevent such transferring and spread of injurious pests, they cannot be fully exterminated when once they obtain a foothold, and in the end each individual fruit-grower must depend on his own efforts.

REMEDIES.

It follows without saying that what we should seek in any direct remedy is, first, perfect killing power, or, to be more exact, perfect insecticide quality associated with harmlessness to the tree; second, reasonable cheapness.

Different Washes.—I will not detain you with any general remarks on the subject of insecticides, because it has received full attention in my official reports. Dry insecticides have been found, in the main, unavailable here, and we must depend upon washes or materials in solution that may be sprayed upon the tree. Here, again, I would remind you of the careful and extended experiments made by Mr. Hubbard in the orange groves of Florida with a view of solving the important question as to what is, on the whole, the most satisfactory liquid application, cheapness and efficiency considered. Carbolic acid, creosote, sulphurated lime, silicate of soda, sulphuric acid, sulphuret of iron, bisulphide of carbon, and many other materials have been thoroughly tried, as well as whale-oil soap, potash and soda lye and their various combinations; but in the end nothing proved equal to emulsified kerosene. Whale-oil soap is an excellent wash for destroying some insects upon some plants, but it fails to kill the eggs of our scale-insects, so that, however good it

may be for scrubbing the trunks and branches of a tree, I cannot conscientiously urge it as, on the whole, satisfactory, particularly as it is known to stain the fruit, and because of the many different grades, varying in their effect and in their value, which are upon the market. Potash and soda lye injure the tree more than kerosene does and do not destroy the insects as well, admirable though they are as washes in weaker solution for some other purposes. The action of sulphurated lime (flowers of sulphur boiled in milk of lime) is very similar to that of caustic potash.

Notwithstanding the kerosene emulsions, in proper proportions, have proved so satisfactory against the scale-insects of the Orange in Florida, they have, as a rule, failed to win the good opinion of the orange-growers in California. I have always believed the want of success in this State with the kerosene emulsions was due to imperfect preparation of them, or to imperfect application. I was inclined to give some credence to the theory advanced by my old-time friend, Prof. E. W. Hilgard, who is so keenly alive to everything that interests you, and whose services have been so invaluable to the agriculture and horticulture of the State, namely, that the dryness of the atmosphere in California induced a more rapid evaporation of the kerosene, which may partly account for the difference in experience between the Atlantic and Pacific. For these reasons I had long desired to make a series of experiments in California, and finally, last year, did have such a series carried on by Messrs. D. W. Coquillett and Albert Koebele. It were difficult to find in the whole State two gentlemen combining in the one instance more care and reliable entomological capability, and in the other more industry, earnestness, and enthusiasm, and this I say without desire to flatter, but as evidence that their experiments, so far as they went, were trustworthy—in fact, I may say, the most careful and thorough that have hitherto been made. These experiments extended over a period of three months in the spring and three months in the autumn, and the detailed reports which these gentlemen have made will be published in connection with my forthcoming annual report. They show that the kerosene emulsions must still be placed at the head of the list of washes, not only for ordinary scale-insects, but for this Icerya or Fluted Scale. Among the different substances thoroughly experimented with were caustic potash, caustic soda, hard and soft soaps, tobacco, sheep dip, tobacco soap, whale-oil soap, vinegar, Paris green, resin soaps and compounds, and so on. It is impossible to give even a digest of the very many experiments, and the varying results obtained with the different washes. It suffices to say that the kerosene emulsion diluted with from eight to ten parts of water was found to kill all the eggs as well as the old females, and that, even when used still stronger, it left the tree uninjured. Mr. Coquillett reports with reference to the much-praised caustic soda, that it has no effect on the eggs of this scale even when applied so strong as to burn the bark and kill all the leaves.

Similarly, the whale-oil soap does not kill the eggs directly, though it may harden the egg-mass so as to prevent the hatching of a large proportion of young larvæ.

Resin Soaps.—Mr. Koebele experimenting through August, September, and October, found similarly good results from the kerosene emulsion, but that the crude petroleum, although much cheaper, was more apt to injure the tree. His attention was, however, directed mainly to the preparation of resinous soaps and compounds on account of their greater cheapness. He succeeded in making a number of these mixtures which, when properly diluted, need not cost more than one-half to one cent per gallon and which produced very satisfactory results, killing the insects or either penetrating or hardening the egg masses so as to prevent the hatching of the young. One of the most satisfactory methods of making a resin soap is to dissolve one pound caustic soda in 1½ gallons water to produce the lye; then dissolve 2 pounds resin and one pound tallow by moderate heat, stirring in gradually during the cooking one quart of the lye, and then adding water until you have about 22 pints of a brown and thick soap. This will make 44 gallons of wash, costing less than one-half cent per gallon.

There is some slight difference between the experience of Mr. Koebele and Mr. Coquillett as to the value of soap washes, and the greater success which the former had with them as compared with the latter was probably due to the fact that his experiments were made during the dry or rainless season. The great point of interest, however, in these experiments is that they confirm in a remarkable manner the experience had in Florida. And I think you will agree with me that they justify the opinions which I have expressed in official writings. Such observations as I have been personally able to make during my brief sojourn among you have greatly served to confirm me in those opinions, and while the resin soaps experimented with by Mr. Koebele are a valuable addition to our insecticides for the scale-insects, I find the experience in Florida repeated here, and all the more satisfactory washes have kerosene as their effective basis. There has been, however, a very great waste in applying it, and it is in this direction that reform is most needed.

The fact cannot be too strongly urged that in the case of this Icerya, as of most other orange-feeding scale-insects, it is practically impossible, with the most careful and thorough spraying, to reach every one of the myriads on the tree. Some few, protected by leaf-curl, bark-scale, or other shelter, will escape, and with their fecund progeny soon spread over the tree again if left unmolested. Hence, two or three sprayings, not too far apart, are far preferable to a single treatment, however thorough. And this is particularly true of the pest we are considering, which lives on so many other plants, and which in badly infested groves is frequently found crawling over the ground between the trees.

Value of Kerosene Emulsion.—It is now the custom to use the time of a team and, say, two men for fifteen or twenty minutes or more, and 30, 40, or 50 gallons of liquid on a single medium-sized tree. In this way the tree is sprayed until the fluid runs to the ground and is lost in great quantities, some growers using sheet-iron contrivances around the base of the tree in order to save and re-use the otherwise wasted material. Now, however much this drenching may be necessary, or has come into vogue, in the use of soap, and potash and soda washes, it is all wrong, so far as the oil emulsion is concerned, as the oil rising to the surface falls from the leaves and wastes more, proportionately, than the water.

The essence of successful spraying of the kerosene emulsion consists in forcing it as a mist from the heart of the tree first and then from the periphery, if the tree is large, allowing as little as possible to fall to the ground, and permitting each spray particle to adhere. It is best done in the cool of the day, and, where possible, in calm and cloudy weather. There has been no morning since my sojourn among you that I have seen the sun rise in a clear sky. Cloudiness has prevailed for some hours after dawn, and in this regard you are favored, as this would be the time of day, of all others, to spray. Proper spraying should be done with one-fifth of the time and material now expended, or even one-tenth of that which I have seen wasted in some cases, so that three sprayings at proper intervals of from four to six weeks in spring and summer will be cheaper and far more satisfactory than one as ordinarily conducted. In this particular neither Mr. Coquillett's nor Mr. Koebele's experiments were entirely satisfactory, as I was too far from the field to permit of the detailed direction necessary.

I cannot emphasize the fact too strongly that it is practically impossible to eradicate, by any system, every individual insect and egg upon a tree in one spraying. It is almost futile to attempt to do so.

Improved Wash recommended.—Let us now see whether the kerosene emulsion, pure and simple, can be improved upon by the addition of any other material. It is plain to be seen from the circulars and documents, both official and unofficial, that have been published in the State and distributed among you, that, in many cases, the proper use of kerosene has been entirely misunderstood. Having already seen that it destroys the eggs of Icerya only when used in the ratio of one part of kerosene to about seven or eight of the diluent, it follows that any lesser amount will give less satisfactory results. Moreover, it is extremely important to prepare the emulsion properly. This has usually been done by the use of milk or of soap, because they are cheap and satisfactory. Raw eggs and sugar, and other mucilaginous substances may be used. Experience has shown that the best proportions are two parts of the oil to one of the emulsifying agent, whether milk or soap, *i. e.*, for instance, two gallons of the oil to one of milk or one of the soap-water made by dissolving half a pound of soap in one gallon of water. So long as these proportions are maintained

a large quantity can be emulsified as rapidly as a smaller quantity, and violent agitation through a spray-nozzle at a temperature of 100°, and as frequently described in my reports, gives the quickest results.

Take, for instance, the mixture recommended by your county board of horticultural commissioners. You will find that with the soap and wood-potash there are twenty-five parts of the diluent to one of the kerosene recommended, and there is every reason to believe that the kerosene in this wash might just as well be thrown away, and that it adds comparatively little, if any, to the efficiency of the wash, at least for the fluted scale. If, on the contrary, we could add to the ordinary emulsion any materials that would give greater adhesiveness, such an addition will prove an advantage. Such we get, to some extent, in the soap emulsion, for which reason it has a slight advantage over the milk emulsion. And after examining the trees treated with resin washes, I am strongly inclined to recommend that these resin washes be used as the diluent to the soap emulsion made after the usual formula. Something similar was tried some years ago by one of my agents in Florida, Mr. Joseph Voyle, who used fir balsam in place of resin, in connection with the oil emulsion, and obtained most satisfactory results. A certain amount of dextrine, or, yet better, flour, if mixed with the wash, would prove valuable for the same purpose.

Again, if permanency can be given to the effect of a wash so that the few insects escaping the first application, or which would hatch out thereafter, would succumb, such addition would be invaluable; and though the arsenites are, as a rule, effective chiefly against mandibulate insects, or those which masticate their food (in other words, although the action of these poisons is mainly through the stomach), yet I happen to know from experience that they have also a direct effect by contact. Therefore I recommend, with considerable confidence, that in this dilute kerosene emulsion there be added a small proportion of arsenious acid, say from 2 to to 3 ounces to every 50 gallons of wash. This arsenious acid may be prepared and added in various ways. Probably one of the simplest would be to take half a pound of arsenic to half a pound of sal-soda, boil this in one-half gallon of water until the arsenic is dissolved, and mix this with about 100 gallons of the diluted emulsion. A quarter of a pound of London purple to 50 gallons of the diluted emulsion, or even a still greater amount, would, perhaps, serve the same purpose and be less likely to injure the tree.

I am aware of the danger of making recommendations that have not yet had thorough trial, but I have already made a few limited experiments (and intend making more) which would seem to justify these, and at all events if care be taken not to use too large a quantity of the arsenic no harm will result from it, either to the tree or to those who use the fruit.

Kerosene is not so cheap as the resin compounds, nor as some of the soap and lye washes, but it has this great advantage, that it can be used in much less quantity. It permits a great reduction in the amount of material and the cost of labor. At the rate of 20 cents per gallon wholesale, the effective wash will cost 2½ cents per gallon, and from one to two gallons are sufficient, if properly sprayed, on a medium-sized tree.

SPRAYING APPARATUS.

Just as there is a great wastage of time and money in drenching a tree with kerosene emulsion, so the spraying nozzle most in vogue with you is also somewhat wasteful. That most commonly used is the San José nozzle, in which the water is simply forced through a terminal slit in a narrow and rather copious jet of spray. It is the force and directness of the spray which gives this nozzle its popularity under the mistaken spraying notions that prevail, and to this I should probably add the fact that, being a patented contrivance, it is well advertised, and on the market, for somehow or other people rarely value a gift as much as what they buy, and too often rate value by price. The Cyclone nozzle, or Riley atomizer, as it is called in France, which has proved so satisfactory in the East as well as to my agents at Los Angeles, has scarcely had such trial among you, so far as I have been able to see, as to properly impress its advantages. That originally made and sent out by the late G. N. Milco, of Stockton, was patterned in size and form after one which I sent him, and which was designed to spray from near the surface of the ground.

What I would use for the orange grove, or for trees, is a bunch of nozzles of larger capacity, the size of the outlet to be regulated by the force of the pump. I have witnessed all forms and sorts of spraying devices, and while there are many that are ingenious and serve a useful purpose, I can safely say that there is no form which will produce a spray so easily regulated and altered to suit different conditions, and which is so simple and so easily adjustable to all purposes. Since among you I have endeavored to get a bunch nozzle, such as I would recommend, made at Los Angeles, and the difficulties I have had in getting it made properly illustrate, perhaps, some of the reasons why this nozzle has not become more popular on this coast. All the parts must be well fitted; the inlet must be tangential and the outlet so made as not to overcome the whirling or cyclonic action of the water. The breadth, directness, force, or fineness of the spray are all regulated by the form and size of the outlet, and if a thick cap be used it must be gradually countersunk on both sides until the thickness at the outlet does not exceed one-sixteenth of an inch or less. A bunch of four nozzles, one arranged so as to have the outlet distal or from the end of the piping, which may be ordinary gas-pipe, and the other three in bunches, so that the outlet is at nearly right angles, each about an inch below

the other, and so placed that they are one-third the circumference of the main pipe apart, will be found, I think, most serviceable in your groves. Such a bunch working from the center of an ordinary-sized tree will envelop it in a perfect ball of mist.

For tall trees a more forcible stream might be had from the end by substituting an ordinary jet with a wire extension. This is a recent device first brought to my attention by Mr. A. H. Nixon, of Dayton, Ohio, and for sending a fine spray for a great distance it has advantages. It is simply an extension screwed over an ordinary nipple, the end of the tube being covered with wire netting, which breaks up the liquid forced through it. The brass nipple should be about one inch in length, the perforation very true and varying in diameter according to the force of spray desired. The nipple screws on the discharge pipe, and upon a shoulder threaded for the purpose is screwed a chamber or tube about one inch in diameter and three inches long, to the outer end of which is soldered a piece of wire gauze varying in size of mesh to suit the force of pump and the size of aperture in nipple.

Finally, if a service of blind caps and several sets of cyclone nozzle caps of varying aperture are kept on hand, the spraying may be adjusted at will to condition of wind, size of tree, &c.

Your worthy president has very well remarked that what we want is not generalization, but hard facts and experience presented in the simplest and briefest manner. If I have dealt somewhat with principles rather than with details, I shall look for your excuse in the fact that extended experience presents such a multiplicity of details as to warn me from entering into them.

FUMIGATION.

Fumigating trees will always have, *cæteris paribus*, some disadvantage as compared with spraying. The mechanism is more cumbersome; the time required for treatment and the first cost in making preparation greater, and these facts will always give spraying the advantage with small proprietors and those who are dealing with young trees. Sulphur fumes have been tried, but they burn the leaves and injure the tree. Tobacco smoke and vapor fail to kill the eggs. Ammonia is excellent, but fails to kill all, though I have known the most beneficial results from the ammonia arising from sheep manure used as a fertilizer in apple orchards. Bi-sulphide of carbon has been tried, and with great care in getting the right quantity its vapor will kill the insects without killing the tree; but its application requires too much time and is fraught with more or less risk to man. This is equally true of cyanide of potassium and of other substances the vapors from which are known to be very deadly to insect life. It will be difficult, therefore, to find a mode of fumigating that will be harmless to the tree and deadly to the insects, and at the same time as rapidly and easily applied as a spray.

Many of you already know that Mr. Coquillett, in connection with Mr. Alex. Craw and Mr. Wolfskill, of Los Angeles, have for some time been conducting a series of experiments which lead them to believe that they have discovered a gas which possesses the requisite qualities. The trees which I have examined that have been treated with this gas, both there, at San Gabriel, and at Orange, lead me to the conclusion that they are fully justified in this belief, and several ingenious contrivances have been perfected in Los Angeles County which give promise of great utility and feasibility. Whether the trees are left uninjured, it is perhaps premature to say. That they are affected is evident in some cases, and what the ultimate effect will be time alone will decide. Let us all hope that the promise of this gas will be abundantly fulfilled. Let me add, however, that even if it be found that no solitary insect or egg will escape treatment with this or any other gas, fumigation will yet no more fully exterminate or free the orchard than the proper spraying of the kerosene emulsion, but, for the reasons already stated, will have to be repeated. In other words, one application, however perfect in destroying insect life, cannot and should not be depended on. The disadvantage about this gas in my estimation is that it is kept so far a secret. We cannot perhaps blame the gentlemen for endeavoring to realize something out of what they consider a valuable discovery that will compensate them for the time they have devoted to the purpose; but I am always suspicious of secret or patent insect remedies. My friend, Mr. Coquillett, perfected this gas after his employment by the Department of Agriculture ceased. But it is a general truth that the moment any person or persons become interested in a patent or in any remedy they desire to control, from that moment their judgment can no longer be depended on as to the value of other remedies.

I have been asked why Mr. Coquillett was not continued in the service of the Department for a longer period, and it is perhaps due to the fruit-growers of California and to him to explain why the experiments which he began were interrupted. It had been my desire to have two agents permanently located on the Pacific coast to carry on the work of my Division here, for I have long felt that your fruit interests, to say nothing of the other agronomic interests of the State, demanded such recognition at the hands of our National Government. It so happens that in my desire to aid other investigations that bear upon the promotion of agriculture, I took part in urging the creation of a Division of ornithology and mammalogy for the purpose of investigating the habits of birds and mammals so far as they affect agriculture and horticulture. The friends of ornithology were successful in getting that Division created, but were unable to get an appropriation to carry on the work, except by taking it out of the appropriation for the Entomological Division; and during my absence from the country last June, and after all my arrangements had been made for work on the Pacific coast on the basis of the appropriation bill passed by the House of Representatives,

the amount was cut down in the Senate and part of it given for the ornithological work, thus requiring the discharge of a number of those already engaged, and restricting the work of the De partment in entomology.

BANDAGES AROUND THE TRUNK.

There is always danger that a tree once sprayed or disinfected will get reinfested from the insects that have not been reached upon adjacent plants or upon the ground, and which in time may crawl upon the trunk. Any of the sticky bandages used for the canker-worm will check this ascent, but when the sticky material is placed directly on the trunk it may do more harm than good. It should, therefore, be placed upon strips of tar paper or other stiff paper, tied by a cord around the middle, the upper end flared slightly outward, and the space between it and the trunk filled with soil to prevent the young insects from creeping beneath. Cotton should not be used for this purpose, as birds, for nesting purposes, carry away particles of it which may contain the young insects and may thus help to disseminate them.

LEGISLATION.

Next to the destructive locusts which occasionally ravage our grain-fields no other insect has perhaps been more thoroughly legislated against than this Icerya in California. Indeed, the manner in which the people of this State have taken hold of this insect question and have endeavored by all legislative means to enforce such action on the part of fruit-growers as best subserve the interests of the whole State, is highly commendable. Yet, while much good has undoubtedly resulted, the laws have too often proved inoperative, either through the negligence or ignorance of those appointed to execute them, or still more often through the indifference or opposition of individual growers, or unwillingness of the courts to enforce the laws with vigor. And while the greatest co-operation should be urged, and, if possible, enforced, in battling with these insect pests, yet, so far as this particular species is concerned, no human endeavor can now exterminate it from the country. It has come to stay, and nothing has more fully forced itself upon my conviction than that, in the end, with all our laws, each orange-grower must depend upon his own exertions. It is, therefore, fortunate that the pest may be controlled by such individual exertions. While, however, we must admit that it is beyond our power to fully eradicate it from those districts in which it has obtained a foothold, the case is quite different when it comes to restricting its spread, and it is in this direction that wise legislation, and the strict carrying out of the legislative measures you have adopted, or may adopt, will be productive of much good.

Recent history has furnished very good evidence of the power of stringent measures adopted by governments, whether to prevent the

introduction of an insect pest or to stamp it out when first introduced and before it has acquired a strong foothold. Several European nations have, in this way, averted, so far, the Grape Phylloxera, and the German Government, on one occasion at least, effectually stamped out our Colorado Potato-beetle, which became established in a restricted locality.

The danger which threatens orange-growing districts in this State not yet affected, as well as the orange belt on the Atlantic seaboard, is great, and we cannot too earnestly appeal to the authorities that be for means to employ still greater vigilance to avert it.

RIVERSIDE.

What a relief it is to get from a scale-infected region, with the attending evils of blighted and withering growth, smuttiness, and unmarketable fruit, into a neighborhood yet exempt from these pests, like this enterprising locality in which you meet! What a joy in contemplating by contrast the bright and cleanly aspect of the trees! And what is there more beautiful in nature than a perfect orange grove at this season, and yet untainted by Coccid or Aphid, or other insect enemy? In all my travels I have nowhere felt nearer the ideal Garden of Eden than in some of your lovely valleys, yet unvisited by these destroying atoms. The profusion and perfection of fruit and flower, the elysian character of the landscape, the genial sun—all appeal to the higher esthetic feeling in man, and one is moved to enthusiastic contemplation and admiration of the glories of nature and the bounties of Heaven under such favoring conditions!

STATE ENTOMOLOGIST.

You know better than I do how your laws have acted in the past and are acting now, and how far your State inspector and your different county inspectors have succeeded.

But, before passing this matter of legislation, I should be derelict in my duty if I did not urge upon you the value of one form of legislation which has not yet been tried. Without abating one iota the work already being done, whether by individuals or boards, it does seem to me that if you had a State Entomologist, *i. e.*, an officer appointed to devote his entire time to this subject of economic entomology in the State, much additional good might be accomplished, provided he were properly supported and given the means to carry on his work effectually. You should not commit the same error that has been committed by some of the Eastern States, in which the cultivators of the soil have desired to have such a State entomologist appointed. In three cases which I now have in my mind there has been quite a disposition on the part of the legislature to pass a proper bill, but it has failed in each case because of the conflicting interests which aimed to control the office. Either the State Board of Agriculture, or a State Horticultural Society, or a State Agricultural College, or some State university, or some other

State institution, desired to have the honor and the privileges pertaining to the office, and, between them all, failure has resulted. I should like to see California with a competent State Entomologist appointed, under a bill carefully drawn up providing his duties, by the governor, upon recommendation of the professor of agriculture in your State university, and the president of such other State horticultural and agricultural bodies as may exist. In this manner the interests of all these bodies might be considered, and the State could not, in my judgment, make a more profitable investment than in the creation of such an office.

IMPORTATION OF PARASITES.

It has doubtless occurred to many of you that it would be very desirable to introduce from Australia such parasites as serve to keep this fluted scale in check in its native land. We have already seen that there is one minute parasite which has, in all probability, been brought over with it from Australia, and there is no question but that it is very desirable to introduce any such of its enemies and parasites as can be introduced. This State—yes, even Los Angeles County—could well afford to appropriate a couple of thousand dollars for no other purpose than the sending of an expert to Australia to devote some months to the study of these parasites there and to their artificial introduction here. But the agent must be an expert entomologist, and his selection should be left to some competent authority. The result for good, in the end, would be a million-fold, and I have no fear but what you, as orange-growers, will appreciate the force of this statement. I would not hesitate, as United States Entomologist, to send some one there with the consent of the Commissioner of Agriculture, were the means for the purpose at my command; but unfortunately, the mere suggestion that I wanted $1,500 or $2,000 for such a purpose would be more apt to cause laughter and ridicule on the part of the average committee in Congress than serious and earnest consideration, and the action of the last Congress has rendered any such work impossible by limiting investigation to the United States.

REMARKS CONFINED TO THE ORANGE.

Let me, in closing, lay stress on the fact that I have, in all that has been said relating to remedies, had reference solely to the orange and the scale insects affecting it.

The Fluted Scale is undoubtedly the most difficult to master, and the means I have recommended against it apply equally to your other orange scales, as experiment has already demonstrated. Your Red Scale, in some respects even worse than the Icerya, and of which I should like to say something in detail did time permit, succumbs to it. But when it comes to the treatment of deciduous trees, much that I have said will not apply, and each tree needs separate consideration and is affected differently by different washes.

PROSPERITY VS. INSECT PESTS.

In passing from place to place since I have been in the State, and more particularly in visiting the different parts of Los Angeles County, I have been struck with the wonderful activity everywhere manifest in real estate. Land is "booming" in all parts of the country, but nowhere has it reached such proportions, it seems to me, as right here in this part of California. There does not, at first, seem to be much connection between the real estate boom and the scale-insects of the Orange. But I am quite sure that the rapidity with which your orange orchards have been and are being converted into town blocks and town lots has a marked influence on the spread and increase of these scale insects; for no sooner does the owner of a grove subdivide and sell it than the different new owners allow it to "run to grass," so to speak, and for miles around all your thriving and growing centers of population may be found neglected orchards upon which the insects are reveling and multiplying and scattering into those which are more carefully cultivated. To this cause is, in my judgment, due very much of the rapid reinfesting of these cultivated orchards, so that your insect troubles are, in a measure, connected with your unprecedented growth and prosperity.

NOT AN UNMIXED EVIL.

Finally, let me say, before taking my seat, that your scale insects are not an unmixed evil. With your lovely climate, rich and varied soil, and the many other advantages which your beautiful country possesses for the cultivation of the orange and most other fruits, the business would soon come to be overdone and rendered unprofitable, could every one, before planting his trees, feel sure of an abundant and fair crop without having to contend with difficulties. Under these circumstances, it seems to me that even the dreaded scale-insects, by driving the thriftless to the wall and giving the careful and intelligent man who persists in destroying and defeating them better prices for his product, may, after all, prove a blessing in disguise. One thing is sure, it is pure folly to talk of giving up the battle and abandoning the field to these, your tiny foes. There is no insect that is invulnerable, or that we may not overcome, if we but attack it at the right time, in the right place, and with proper means and ability. You will, ere long, feel yourselves masters of the situation, and if what I have said will aid in ever so little to give you the victory I shall feel abundantly rewarded. I have already occupied more of your time than I intended to, and though much is left unsaid, even about this single insect, I must close in order to leave time for discussion. In doing so, permit me to congratulate you as a Board for the good work already done, and to prophesy that in future years when the fair and unrivaled fruit of this coast shall have multiplied beyond the most sanguine vision of any of us, and have found its way in one form or another to consumers in all parts of the world, the people of California will gratefully remember the work you instigated and the battles you fought. Ladies and gentlemen, I thank you.

NOTES ON ICERYA—ITS PROBABLE ORIGIN THE ISLANDS OF BOURBON AND MAURITIUS.

C. V. Riley in *Pacific Rural Press*, June 11, 1887.

I have just read with a great deal of interest the letter of W. M. Maskell to State Inspector Klee, in your issue of the 7th instant. This letter really brings up quite an important question, so far as our White or Fluted Scale is concerned. In an article in my forthcoming report, as United States Entomologist, of which I have sent you advanced page proofs, I have, without question, assumed that *Icerya purchasi* Maskell was a good species and distinct from *I. sacchari* Signoret, because Maskell, in his second article on the former species (Trans. New Zealand Inst. for 1883, page 140), after an examination of specimens of *I. sacchari*, sent him by Signoret, says that he finds the "Mauritian species undoubtedly and markedly distinct." This letter to Mr. Klee brings up, however, the whole question of the accuracy of his determination. He admits that he has never seen Signoret's *I. sacchari* alive. The only differences which he made in 1883 between *I. sacchari* and *I. purchasi* are as follows: "*I. sacchari* does not seem to form an ovisac with longitudinal grooves, nor does the body of the insect, although somewhat hairy, show the great tufts of black hairs and the curious projecting glassy tubes springing from large brown coroneted bases which are marked features of *I. purchasi*. The number of circular spinneret orifices are much smaller in the Mauritian insects."

Now Signoret knew only two stages, the full-grown female and the newly hatched larva, while Maskell gave careful descriptions of the egg, the young larva, the second stage, and the full-grown female, but had not seen the male larva, cocoon, or adult. It is for this reason that I have given a very full characterization of the species in the article already alluded to.

Signoret's description, so far as it goes, applies thoroughly well to *I. purchasi* in some of its forms. His female had not formed the cottony or fluted-egg covering, at least he makes no reference to it. His figure, while showing a short truncated mass, does not indicate the flutings because the few lines upon it are evidently intended by the artist for

the long, fine, glassy hairs. Maskell, following Signoret's description, rightly says that *sacchari* "does not seem to form an ovisac with longitudinal grooves." But Signoret himself says that *sacchari*, in the island of Bourbon, "is confounded with *Lecanium gasteralpha*, under the name of louse-with-the-white-pocket." Whether Signoret assumed such confounding by the islanders because of erroneous supposition that this *sacchari* had no ovisac, or whether the islanders designate both the *Lecanium* and the *Icerya* under the characteristic vernacular, is not plain from the language, and is immaterial. On the principle of unity of habit in the same genus, I feel morally sure that Signoret's *Icerya* must produce her eggs in such an ovisac, and the Bourbonese are doubtless well aware of the fact, otherwise they would not so indicate it or confound it with *Lecanium*. We are justified in assuming that the female which my friend Signoret described and figured had only just begun forming its sac, and that its flutings had become effaced and the secretion unnatural in appearance. Maskell's second reason, viz, that *sacchari* "does not show the great tufts of black hairs and the projecting glassy tubes," will also lose force from the facts that Signoret particularly describes these glassy tubes as "long filaments, waxy, very fine, delicate, transparent," and that these tufts of black hairs are extremely variable in quantity, sometimes making the insect look quite dark and bringing out in strong relief the few smooth, orange-red or brick-red elevations, and particularly the series of about twenty-two around the border; at other times being so scarce that the insect has an almost uniform reddish-brown appearance.

It would appear, therefore, that, notwithstanding the differences in Signoret's and Maskell's characterizations, there is room yet for grave doubt as to the specific difference in the two insects, especially as upon restudying Signoret's description it accords in every other particular with *I. purchasi*.

You will pardon me, I know, for going into these technical details, because it is evident that the solution of these questions has a very important bearing. My own impression now is that future investigation will prove that the two insects are identical. The truth will in time be ascertained by getting all the different stages of *sacchari* from the Island of Bourbon or from Mauritius, and comparing them more carefully with *purchasi*, the different stages of which I have fully detailed in my report.

Let me say in this connection that there is a great variability in *purchasi* as to the amount of matter secreted on the scale itself, which may very easily mislead, especially in dried specimens. In the orange groves of Southern California the general colorational aspect of the insect is, in all its stages, reddish-brown, the surface exudation being rarely excessive and never obliterating the reddish-brown color. This exudation is, in fact, more noticeable upon the male larva, which, together with his narrower, more elongate form, renders him easily distinguishable

from the female. In the more northern parts of the State, however, I found that the general colorational aspect was quite different, owing to the greater excess of the surface exudation, which frequently covers the body in little globular masses and gives it a whitish and even greenish aspect, and which often rises along the middle of the body into a tufted ridge. This form corresponds more nearly with what Signoret has described, and it follows that this waxy surface exudation becomes denser and still more noticeable by contraction in the dried or cabinet specimens or whenever the insect has shrunken.

This question of the synonymy of the species bears directly on its original source; for if we have but one species of the genus, or even if there be two, and *I. purchasi* is found to occur on the sugar cane in the islands of Bourbon and Mauritius, then the presumption will be that it originally came from these islands. In my address at Riverside, I called attention to the fact that this Fluted Scale seems to have become notably injurious almost simultaneously in Australia, South Africa, and California, and on the assumption that it infests the sugar cane on the islands mentioned, it is much more easy to understand its introduction to the other countries. Sugar is exported from those islands into many parts of the world. The sugar, as it leaves those islands, is very coarse, and all the molasses or sirup is not extracted, centrifugals not being in use. For the purpose of draining, the sugar-makers are in the habit of putting a piece of cane in every hogshead, and, in addition, the top is sometimes covered with pieces of cane. In point of fact, I am informed that an insect, known in the trade as the sugar-louse, is of quite frequent occurrence in such sugar, and Professor Wiley, of the Department of Agriculture, upon being shown specimens of *Icerya purchasi* (and he is quite familiar with the so-called sugar-louse), informed me that he thinks them identical.

On this hypothesis the initial spreading point is from some of the Pacific islands, and the insect probably made its way first to Cape Town and thence to Australia, New Zealand, and California. This does not preclude the possibility of its importation upon other plants, but I think it highly probable that the chief method of distribution of an insect which is so tough as to bear long survival without food was upon sugar-cane in sugar hogsheads, or bags, as it could be much more safely carried in this way than upon living plants. The determination of the original source of the pest is of vital concern in any study of its parasites, as such would be more apt to be found in its native country than in any countries of its introduction.

I have been quite anxious to settle definitely this question of its original home, and have lately had some correspondence with parties in Australia, New Zealand, and Africa. The following extracts from such correspondence will prove of interest to the people of California. Mr. Kirk's statement will add weight to the hypothesis that I have ventured, while Baron von Mueller's statement also strengthens it. It may per-

haps be impossible at this late day to definitely settle the question of this original source, especially as there may have been not one but several introductions (indeed we have evidence that such was the case) into all three of the countries in which it now occurs; but we can much easier understand its travels if it started as a sugar-cane insect. I have italicized those parts of the following letters which particularly bear on the subject of this communication.

The sketch of the Dipteron, which Mr. Crawford found attacking Icerya, shows a great likeness in the body to some hymenopterous Encyrtids; but the wings indicate its Dipterous character and that it belongs to the Dolichopodidæ near *Diaphorus*. So far as their larval habits are known, these flies are predaceous and live in the larva state in the ground. Perhaps Mr. Crawford has used the term "parasitic" synonymically with "predaceous," but I will not further anticipate what Miss Ormerod may report.*

EXTRACTS FROM CORRESPONDENCE.

[The following are the extracts from the correspondence to which reference is made above.—EDITORS PRESS.]

Letter from Roland Trimen, of Cape Town, to Professor Riley.

As regards the evidence as to the Australian habitat originally of this insect, I regret that I have nothing to add to what has been already supplied to you.

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Since the commissioner's report in 1877, the orange industry of the western districts has suffered most severely, scarce, very inferior, and exceedingly dear fruit being now only obtainable where it used to be abundant, good, and cheap. Where, however, the kerosene and alkaline solutions have been constantly applied by individual proprietors here and there, the result (as I am informed by Mr. MacOwan, director of the botanical gardens) has been very encouraging. In the eastern districts the effects of the Icerya's attacks do not seem to have been nearly so serious, but whether this is due to a less suitable climate and other conditions, or to more vigilance and exertion on the part of cultivators, I cannot at present determine.

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* Since this was written I have received two specimens of the insect itself through the courtesy of Miss Ormerod. These specimens are so much mutilated that it is almost impossible to accurately place them. The enlarged figure sent by Mr. Crawford was very misleading, the venation of the wing being wrong and also the antennæ. It has no second cross vein on the wings and no sort of resemblance to the actual antennæ, while the two basal cells on the wings are lacking. It is quite likely that this fly belongs to a new genus. The specimens were sent to Dr. S. W. Williston, who reports that he considers them Oscinids, but that further than that he could venture no opinion as he can locate them in no genus with certainty.

In reference to natural enemies of the Icerya, it is of interest to note that a little lady-bird, *Rodolia icerya*, of which Miss Ormerod has sent me a figure, has been found to do good work and to destroy the pest in Australia, while news comes from California that *Chilocorus cacti* is doing such excellent work that the trees in some localities are being entirely freed through its instrumentality and the lady-birds are actually being sold to orange-growers at so much per ounce. C. V. R.

The bug spread to Natal within the last few years, and last year I received specimens of them, found on the common black wattle. Only yesterday I was sorry to receive a lot found there on the orange.

No public action in the matter has been taken since the legislative assembly, in 1887, threw out the attempted legislation on the subject. [Roland Trimen, South African Museum, Cape Town, Cape of Good Hope, February 8, 1887.

F. S. Crawford, Adelaide, to Professor Riley.

Last year I entirely lost my colony of Icerya, owing to the attacks of a fly. A rough tracing of an unfinished drawing of the same I also forward. I know nothing about the Diptera and should be obliged if you can determine the insect from the drawing. I may say that I sent Miss E. Ormerod specimens of the fly about two months back, but, of course, have not had time to hear what she makes of it. This is the only instance I know, or have read of, of a true Dipteron being a Coccid parasite. [Frazier S. Crawford, surveyor-general's office, Adelaide, South Australia, February 21, 1887.

Letter from Baron von Mueller, of Melbourne, to Professor Riley.

* * * I beg to inform you that the *Icerya purchasi* (or a closely allied species) although occurring on *Acacia mollissima* and some congeners in the colony Victoria, has not attacked here (so far as I can learn or had occasion to observe), destructively attacked, the orange orchards. I will, however, make further inquiries as well in this colony as in New South Wales, South Australia, New Zealand, and let you know the results.

Possibly the Icerya develops more readily in a moister clime than that of Victoria, and thus becomes more mischievous in California than here.

The introduction of this destructive insect into your States by means of Acacia seems to me very unlikely, because the various species of Acacias are so easily raised from seeds that no one will think to introduce them by living plants. Moreover, it could not have been the Acacia latifolia, which was the host of Icerya, because that species is a native only of the north coast of Australia, and as yet nowhere existing in horticulture. Acacia armata certainly is grown for hedges, but always raised from seed, chiefly obtained from North Australia. It seems, therefore, more likely that when Acacias are grown anywhere, they would afford—particularly in humid climes—a favorable opportunity for the Icerya to spread. A similar circumstance occurred in Ceylon, and another in some parts of Brazil, where an indigenous insect plague became aggravated, when Eucalyptus, on which that insect preferably seized, became reared.* Whether the Icerya was originally an inhabitant of Victoria or merely immigrated, I will endeavor to ascertain; but such a subject of inquiry is surrounded with difficulty now after half a century's existence of the colony, particularly as the Icerya drew no attention here by any extensively injurious effects on any cultivated plants, though it may have caused on some plants minor or transient injury. [Ferdinand von Mueller, Melbourne, Australia, March 21, 1887.

Letter from L. M. Kirk, of Wellington, New Zealand, to Professor Riley.

On returning from a protracted tour of forest inspection in the South, I find your letter of 22d December awaiting reply. My friend Baron von Mueller is mistaken in supposing that I have written recently on the *Icerya purchasi*. In a report on Fruit Blights printed two years ago, I drew attention to the pest, intending to treat at greater length at an early date; but my duties as forest conservator have prevented the intention from being carried out.

The insect is a native of the Fiji and other Pacific islands, from whence it has migrated, probably with orange trees, to Australia, New Zealand, and California. Mr. Maskell states,

* Always from seed.

I believe, that it is a native of Australia, and was introduced from that country on mimosa plants; but this is an error, and Acacias are rarely or never introduced as living plants, owing to their being so readily propagated from seed.

The Icerya is abundant in the northern and middle parts of the Auckland district, and usually prefers citraceous fruits; it is, however, found in large quantities upon some of the wattles, evincing a decided preference for the silver wattle (*Acacia dealbata*). It is, however, occasionally found on furze, manuka (*Leptospermum scoparium*), peach and apple, but on these fruits only in small quantities, and not, so far as I am aware, doing serious damage; in fact it is only found upon these plants when growing in the neighborhood of infested Citrads. It is occasionally found on a few native trees, but it is not causing any great injury.

It is also found in Napier and other parts of Hawke's bay, on the eastern coast of North Island, and in Nelson, and the northwestern corner of the South Islands. It is also said to be found in Canterbury, but I have no direct evidence of its occurrence in that district.

It is not found either in Taranaki or Wellington, in the North Island, except Nelson and possibly Canterbury.

There can be no question that it is a serious foe to citraceous fruits and to wattles. In the vicinity of Auckland, and in many other parts of that district, it is abundant. I have seen trees greatly injured by its ravages, but cannot say that I have seen any killed. At present orange culture has not attained large dimensions here, but there can be no question that Icerya is the worst foe our orange-growers will have to encounter.

I have not seen an Acacia killed by this pest, although the under surfaces of branches are frequently covered. In a few established orange grounds the yield of fruit is materially diminished by the ravages of this insect.

No official documents have been published respecting the Icerya except the Fruit Blights report already mentioned, of which a copy of a Queensland reprint is inclosed herewith. The forest department has purchased Mr. Maskell's account of Scale Insects and is about to publish the same with colored plates. A copy shall be forwarded as soon as it leaves the press. [L. M. Kirk, General Crown's Land Office, Forest and Agricultural Branch, Wellington, New Zealand, March 25, 1887.

From an article by E. J. Dunn, in Melbourne Argus, August 1886.

I desire to call attention to a species of Coccus known as *Dorthesia. This destructive pest was first observed on the island of Bourbon. Thence it spread to Mauritius, about 25 years since. In Mauritius it destroyed the orange and lemon trees, many of the ornamental shrubs and Acacias, and wrecked most of the beautiful plantations and shrubberies. At Port Louis it still exists in loathsome masses on the handsome Talipot palms.*

About 12 years ago it was noticed for the first time in the Botanical Gardens, Cape Town, and most probably arrived there from Mauritius with plants sent to the Botanical Gardens. During the first summer it spread about three miles into the suburbs along the railway. Its fearfully destructive character now became evident, for the orange trees, the Australian wattles, the pittosphorums, and the blackwoods became loaded with this disgusting parasite, and the trees slowly but surely succumbed to its attacks. * * *

All trees of the orange kind, such as lemon, citron, shaddock, &c, proved especially suitable food for the Dorthesia, and once a tree became infested no amount of syringing or washing prevented its destruction. The disastrous results of its arrival at the Cape are all too evident.

Formerly in Cape Town itself, and throughout the suburbs, the orange tree lent a charm to the gardens that no other tree could give, and in the Western Province orange-growing formed a most important source of wealth, many farmers netting several hundreds a year from their orange groves. Some of these groves, planted by the

Huguenots and their descendants, were of great age, and, besides being profitable, were objects of great beauty. Those of the Pearl, French Hock and Wagenmaker's Valley were especially famous.

To-day this is all changed, and, except for a few dead stumps, these fragrant groves and this valuable asset in the country's wealth have disappeared.

Not so the Dorthesia; it is still advancing steadily, and leaving destruction in its wake, and will continue to do so as long as suitable food is within reach.

THE USE OF GASES AGAINST SCALE-INSECTS.

[Reprinted from Bulletin No. 71, Agricultural Experiment Station, University of California.]

Some time ago the Agricultural Department was requested by Messrs. A. B. and A. S. Chapman, Mr. L. H. Titus, and Mr. J. C. Newton, prominent orange-growers of Los Angeles County, to conduct experiments with the view of determining the efficacy of certain gases as insecticides, with special reference to the White Scale, *Icerya purchasi*. The following is a summary of results, of which a full report will be published hereafter:

The use of gases for this purpose has been long contemplated, and various appliances have been suggested for the ready application of any efficacious gas. The ease with which gas penetrates to all parts of the tree naturally suggests its use as preferable to washes, which at best leave many parts of the foliage and infested branches untouched, even when sprayed with the greatest care. In order that the gas may be an efficient insecticide it must be so poisonous that even when applied in small quantities it produces fatal results; for in the application the air confined in the tent covering the tree dilutes the gas to a great extent. Again, the gas must be capable of being generated quickly in sufficient volume. The record below shows that only one of the gases employed fulfilled these conditions to a satisfactory extent. Preliminary experiments with some others having shown their unfitness for the purpose, either on account of expense or because of injury to the foliage, or imperfect action on the insects, their study was not pursued further.

APPLIANCES FOR APPLICATION.

The tent for covering the tree is made of heavy bed-ticking, thoroughly oiled with linseed oil. This cloth serves the purpose best, as it is very closely woven, is pliable and easily folded.

The support of the tent, devised by Mr. Titus, is a very ingeniously contrived scaffolding mounted on wheels, which serve to move it from one tree to another. Its dimensions are 26 feet high, with a base 20 by 20 feet. Its upper part is 20 by 12, and carries upon the top a roller made of galvanized iron (6 inches in diameter and 12 feet long), upon which

the tent is rolled when taken from the tree. Side guy-ropes are attached to the bottom of the tent and run through pulleys at the upper corners of the scaffold. They are used to open the tent when it is to be dropped over the tree, and to fold it up when it is removed. The lightness of the apparatus allows of its being easily removed by two men, who operate the whole. If necessary, two or more tents can be handled by the same scaffolding, one tent being left over the tree while the scaffolding is moved to the next.

In adjusting the tent, the bottom is placed on the ground about 3 feet from the tree and covered with earth. This brings the gas to bear upon the base of the tree and the surrounding soil.

The Generator in which the gases were produced consists of a heavy sheet-iron cylinder, 11 inches in diameter and 13 inches high. The bottom rests on a plank, and to the top is fitted a movable cover suspended in a frame by a bench-screw. Into the cover are fitted two pieces of gas-pipe, one for the exit of the gas toward the tent and the other, connected with a pump, carries the gas which returns *from* the tent. Two small reservoirs are also inserted in the cover; in these are contained the solutions which are to flow into the generator for the production of the gas.

In order to establish circulation and to force the gas into the tent, a pump is used which also serves to exhaust the gas from the upper part of the tent and to force it again through the generator. It is proposed to replace the pump by a small fan-blower, which is much more expeditious than the common pump which was used.

THE GASES EXPERIMENTED WITH.

Among the gases used were chlorine, sulphureted hydrogen, ammonia, carbon bisulphide, carbon monoxide, carbonic acid, hydrocyanic acid, and carbolic acid vaporized by heat.

Chlorine.—Some preliminary experiments were made in small vessels into which this gas had been introduced. Some infested branches were allowed to remain in them for times varying from five to thirty-five minutes without any noticeable effect being produced on the insect. Atmospheres more strongly saturated with the gas proved fatal to the insect in a short time. In other treatments extending over eighteen hours, with less saturated atmospheres, only a small percentage of the insects was killed. No decided effects were noticeable on the foliage unless the gas was very concentrated.

Carbon Bisulphide.—A lime tree, 12 feet in diameter of top, was treated with the vapor of 2½ pounds of sulphide of carbon for forty-five minutes. At the end of this time the insects were lively, and during the treatment had crawled up and collected around a rope surrounding the tree at the point where the gas was being injected from the hose. It proved that the gas thus used injures neither the insects nor the foliage.

It is upon record, however, that in cases where the vapor has not been thoroughly diffused, but was allowed to flow down from an open vessel placed in the top of the tent, serious injury was done to the foliage at points where the undulated vapor flowed down.

Sulphureted Hydrogen.—Several treatments with this gas were made on a small scale, the application lasting from five to thirty-five minutes. The effects produced either with diluted or concentrated gas were similar to those produced by chlorine, except that even the concentrated sulphureted hydrogen did not injuriously affect the foliage. An experiment in which a whole tree was treated in the tent for forty-five minutes with quite concentrated sulphureted hydrogen gas, showed clearly that the effect was far from being satisfactory; the insects for the moment were stupefied, but in the course of an hour and a half the majority of them were again moving about.

Ammonia.—The vapor from one pound and a half of strong ammonia water was applied to an 11-foot lime tree for 30 minutes. The results were disastrous to the foliage; the leaves were all scalded, and in a few days all dropped from the tree, and even the newer growth of wood was injured. The insects, however, were not perceptibly harmed.

Carbon Monoxide.—Very strong hopes have been entertained by many for the successful application of this gas. Its apparent cheapness and easy production, when the necessary plant is once erected, would recommend it. Unfortunately our experiments show that it is not sufficiently effective to warrant its use. The gas was obtained by forcing air through a small furnace filled with red-hot charcoal, care being taken to cool and to measure the gas before applying it. No appreciable effect was noticeable after 40 minutes. In a duplicate experiment, in which the charcoal was more strongly ignited and continuously introduced into the barrel for 30 minutes, only slightly better results were obtained.

Oxalic Acid.—It was thought that the production of carbon monoxide by decomposition of oxalic acid by heat might be substituted for the previous method of generating this gas. One-quarter of a pound of oxalic acid was ignited, and the gases applied in a manner similar to that of the preceding experiment. Neither the insects nor the foliage were harmed in the least. This experiment has incidentally shown that the vapor of formic and oxalic acids, also produced during the heating of the latter, is likewise ineffective.

Carbolic Acid.—It had been suggested that carbolic acid vaporized by heat would prove fatal to the insect. A dose of half a pound of liquid acid was volatilized in the furnace, and the vapor blown in the vessel containing the infected branch. At the end of 20 minutes all the old insects were still alive, and some of the young ones, just molted, were moving about. An hour later the foliage appeared as if scalded.

Hydrocyanic Acid.—It was only with hydrocyanic or prussic acid (generated by the action of sulphuric acid on potassium cyanide) that suffi-

ciently fatal effects were secured to warrant a more thorough determination of the time of exposure and quantities of material which would produce the best results. Numerous experiments were carried on for this purpose, and it was shown that even small amounts were effective. It was also shown that even in these small quantities an injurious effect upon the foliage was produced. In the beginning of the experiments, "mining cyanide" of potassium was used. It is a very impure material and contains along with the cyanide a considerable amount of carbonate of potassium. For this reason many of the first treatments were practically ineffective.

Later treatments with pure cyanide were more successful in destroying the insects, but the foliage was proportionally injured. Treatments varying in dose from 4 to 12 ounces of cyanide, and in time from 15 to 60 minutes, showed that the effect produced on the foliage by longer treatment was not proportionally greater than that produced by short treatment. Neither was the effect of longer treatments proportionally more fatal to the insects. It was thus clearly shown that the gas mixture should be of considerable strength in order to insure rapid action.

The effect of the gas was so disastrous to the foliage that it became necessary to find some means of remedying this trouble. This was sought in applying a second gas, which might preserve the foliage. Sulphureted hydrogen was therefore injected into the tent, together with the cyanide gas, both from the same generator; a portion of the sulphureted hydrogen being introduced before the cyanide was generated. It was found that the insects appeared stupefied when the tent was raised, but large numbers revived in a few hours. The effect of the cyanide seemed therefore to have been decreased by the sulphureted hydrogen. The foliage was not preserved, although not so badly affected as by treatments with cyanide alone.

Carbonic acid gas was next tried. Trees were treated with larger doses of cyanide than heretofore used, and the carbonic acid from 1½ pounds of carbonate of soda was at the same time introduced with these doses. The insects were killed and the foliage of a 12-foot tree remained unharmed, while that of a 14-foot tree with the same amount of carbonic acid was slightly injured. Thus it was shown that it would require 1½ pounds of bicarbonate of soda to preserve tree tops 12 feet in diameter, and that with this protection the deadly cyanide could be successfully used.

The regulation of the doses for the different sized trees so as to produce uniform treatments is calculated on the basis of the results of the experiments which determined the amount of each constituent for a 12-foot tree. The following table indicates the amounts for trees of different dimensions of top, based upon the rates of cubical contents:

Size of tree.	Cyanide of potassium.	Bicarbonate of soda.	Sulphuric acid.
Feet.	*Fluid ozs.*	*Pounds.*	*Fluid ozs.*
4	.7	.05	.4
5	1.6	.11	.3
6	2.5	.20	1.3
7	4.0	.29	2.1
8	6.0	.44	3.1
9	8.5	.63	4.5
10	11.5	.87	6.2
11	15.5	1.14	8.2
12	20.0	1.50	11.6
13	25.4	1.90	13.5
14	31.6	2.50	16.6
15	39.2	2.92	20.7
16	47.5	3.55	25.2
17	57.5	4.23	30.1
18	67.7	5.05	35.8
19	70.9	5.93	42.1
20	90.5	6.93	49.2

In order to apply the doses easily they are prepared so that the required amounts of each ingredient can be directly measured. The cyanide solution is prepared by dissolving, say, 10 pounds of the solid salt in about 2¼ gallons of water, warmed nearly to the boiling point, stirring at intervals, cooling, and then diluting to 2½ gallons. This solution will contain about one ounce of cyanide of potassium to 2½ fluid ounces of the liquid.

The bicarbonate of soda is pulverized finely and measured off in a vessel marked, so as to designate pounds and fractions of a pound of the solid material. It is then placed in the generator, and the dose of cyanide mixed with it, and, if necessary, a little water added to make it into a thin paste. After adding the measured dose of sulphuric acid, the pump is worked slowly at first, and more rapidly after the gas has passed into the tent. The time for each treatment must be determined by future experiments; fifteen minutes seemed to be quite sufficient when the cyanide alone was used, but it may be desirable to extend the treatment to thirty minutes when the foliage is protected by the carbonic acid gas.

It is advisable that the treatments should follow cultivation after about four days, so that all weeds and places where the insect may find lodgment would be destroyed. The insect will then be on, or very near, the tree; the fitting of the tent to the ground is thus also much easier.

The eggs of the insect remained apparently uninjured wherever protected by the woolly covering. A second treatment, to destroy such as may afterward hatch, will, therefore, be necessary.

It must not be understood that these experiments definitely settle the mode of operation and the size of the doses to be used. They are merely suggestive of a general plan which can be so perfected in the future that the application of this remedy to other kinds of trees and insects must be attended with good results. It simply remains for the ingenious cultivator to devise the necessary appliances for its use, on a small scale, on all sorts of fruit trees, shrubs, and plants.

It must not be forgotten that extreme care in the handling both of this deadly gas and of the cyanide itself is necessary. To inhale the one or to taste or touch a wound with the other may lead to serious consequences.

F. W. MORSE.

BERKELEY, *June* 12.